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NARRAGANSETT MARINE LABORATORY
of the
UNIVERSITY OF RHODE ISLAND

FC

Reference No. 57-4

FOULING PROJECT

1 January 1956 - 31 December 1956

KINGSTON, RHODE ISLAND

NARRAGANSETT MARINE LABORATORY
University of Rhode Island
Kingston, Rhode Island

Reference No. 57-4

FOULING PROJECT

1 January 1956 - 31 December 1956

Approved for distribution [signature]
Acting Director

Annual Progress Report
Submitted to the Head of the Biology Branch
Office of Naval Research
Under Contract Nonr-396(06) (NR 163-312)

February 1957

FOULING PROJECT
ANNUAL REPORT
1 January 1956 - 31 December 1956

NR: 163-312

Contract: Nonr-396(06)

Annual Rate: $7,500.00

Contractor: University of Rhode Island

Senior Scientist: Charles J. Fish, Ph.D.

Principal Investigators: Donald J. Zinn, Ph.D.
Richard D. Wood, Ph.D.

Assistants: Benjamin F. Potter, Jr., 19 September 1955 to 22 June 1956
Harold Berkowitz, M.A., 1 July 1956-

Title of Project: The Biology of Marine Fouling Growths On and Adjacent to the Bottom.

OBJECTIVES

The purposes and reasons for this research as described in the proposal to the Chief of the Office of Naval Research, dated 23 December 1954 are as follows:

1. "to determine the nature and amount of fouling growth on and adjacent to the bottom, and its variations with season, depth, sediment type, and turbulence in different representative localities...

2. "to identify and evaluate the major environmental factors responsible for the observed variation, with particular attention to the influence of scouring on the composition, quantity and vertical distribution of the growth in different environments...

3. "the multiple factors involved in the action of turbulence of varying magnitude on different sediment types and fouling communities at different seasons in the bay and open coastal waters are as yet little understood. Differing both in character and environment from that at and near the surface, the bottom fouling population presents a distinctive set of problems..."

The current program became effective on 1 March 1955, and the first field installations were made on 13 April 1955, six weeks having been required for the construction and assembling of test equipment.

The first annual report of this project (Ref. No. 56-11) contains the details of the methods and procedures used in the investigation. These will not be repeated here. The part of the investigation involving the fouling of mines was terminated on 31 December 1955, and the results of this fouling are listed (Op. cit.).

METHODS AND FIELD DATA

1. The apparatus and location of station areas are shown in Reference No. 56-11, Fouling Project, 1 March 1955 to 31 December 1955, as follows:

   a. Type "B" slide box (used at Station DOCK), Fig. 1.

   b. Position of 3-box apparatus in situ, Fig. 2.

   c. Position of 1-box apparatus in situ, Fig. 3.

   d. Position of 5-box apparatus (type "B") in situ, Fig. 4.

   e. Location of Stations ABLE, BAKER and DOCK on chart, Fig. 5.

   f. Using the 3-box apparatus with 4 x 5 inch bevel-edged glass plates (Stations ABLE and BAKER) samples were taken weekly except when adverse weather conditions prohibited collections. However, the interval between collections was never more than two weeks. Two slides were removed from each box at every visit: one after one week's exposure, and one that had been exposed for two weeks. Once a month the accumulating slide was removed for examination and photography.

   g. Five-minute plankton hauls were made on all slide collection dates with a one-foot No. 2 mesh net at the surface. All of the plankton hauls have been preserved, labelled and filed in the laboratory.

   h. The large 1-box apparatus was hauled, photographed and sampled at least once a month.

   i. At Station DOCK, there are five boxes with one, two, three, four or five slides being exchanged on a regular schedule. Additional slides are present for the examination of fouling accumulations, photographs, additional experimentation, etc. The apparatus as presently constructed is easily operated and works efficiently.

2. Accumulation of Data:

a. Station ABLE sampled 53 times.

b. Station BAKER sampled 54 times.

c. Station DOCK sampled 39 times.

d. Samples from all Stations totalled 753.

e. Five-minute surface plankton hauls were made 107 times.

f. Photographs, including field photographs, macrophotographs and microphotographs, 217.

g. Taxonomic specialists consulted, 15.

SUMMARY OF RESULTS

A. <u>General Considerations</u>

1. In this project, the severity of fouling on the test apparatus is shown to depend on the season of the year, the distance of the testing apparatus from the bottom, the rate at which the attached organisms grow, the bulk attained by successive layers of growth, and the length of time the test apparatus remains in position.

2. In addition, severity of fouling presumably depends on the numbers of larvae and swarm spores at attachment stages present in water washing the test apparatus. Sufficient data to validate this hypothesis were not collected.

3. The organisms collected from the test panels are listed in the Appendix. The list is a composite of organismal materials recorded from Station ABLE (mid-bay), BAKER (in coastal water) and DOCK (close to shore, near mouth of West Passage). Many of the forms forwarded to specialists for identification have not yet been returned.

4. The temperatures at the surface and the bottom at Stations ABLE and BAKER showed a two-week lag behind those of the previous year. It started in March and April with an unusually cold spring and lasted through the remainder of the year. The final measurements in December, 1956, were 4.5°C higher than those of 1955.

5. The average difference between surface and bottom temperatures at Stations ABLE and BAKER was less than 0.5°C, and at no time was it greater than 2.0°C.

6. The temperature curves at Station ABLE followed closely those at Station BAKER, except that they rose more rapidly in June, remained from 2.0°C to 2.5°C higher during July, August and September, but returned to the Station BAKER

norm by the first part of November.

7. Turbidity or light penetration measurements and salinities, although recommended, were not made.

8. Mytilus edulis and Obelia sp. (Figs. 1-9) as well as other foulers common to all stations were present at the same levels, in approximately the same abundance, but showed little significant monthly correlation.

9. Evidence has been gathered throughout the year for the movements of Mytilus edulis, Molgula manhattensis and some of the ciliates, on test slides. Because these are prominent members of the fouling community, it is important that experiments be made to indicate how these apparently unpredictable random migrations affect the fouled areas.

10. A preliminary comparison of DOCK, BAKER and ABLE indicates that these stations should be ranked in this order with regard to numbers of kinds of animals and plants, and apparently also in numbers of individuals, except for the bacteria, which appear to be most abundant at ABLE. There are some forms - about 50% - that are common to all three stations.

B. Fouling of 3-Box Apparatus (Stations ABLE and BAKER)

1. Surface and bottom temperatures at Station ABLE did not differ significantly from those at BAKER at any time of the year. With the exception of the two-week period in May, 1956, when there was a difference of nearly 3°C, the variation was virtually always much less than 2°C (Figs. 1-9).

2. Water temperatures from the middle of March, 1956, through December, 1956, showed a two-week lag. This was caused presumably by subnormal air temperatures for this part of New England during March.

3. The fauna at Station ABLE had a generally different composition from that of 1955. This was particularly emphasized by the almost complete absence in 1956 of one of the two dominant 1955 organisms, a mud-sediment tube-dwelling polychaete, and the mollusc Crepidula fornicata.

4. The fauna at Station BAKER did not differ as much in community composition between 1955 and 1956 as it did at Station ABLE, but there were definite observable quantitative differences.

5. Conclusions (3) and (4) above provide additional evidence of the annual variation in the composition of the fouling community in numbers and kinds. These conclusions indicate in addition that an investigation of the make-up of a marine fouling association cannot be satisfactorily completed in two years.

6. Figures 1 through 3 do not present a complete picture of the presence of fouling organisms at Station ABLE, because only six representative organisms or organism groups were selected for illustration. The following conclusions regarding the seasonal fouling of these organisms at Station ABLE (Figs. 1 through 3) apply in large measure to most of the remaining regular foulers.

   a. The rate of settling varies with the location of the sampling area, the species of organism, and the water stratum.

   b. The total annual biomass of the foulers most common to all three levels is roughly the same. Variation in this datum is often the result of mass settling of an accidental fouler, or a fouler unique to the area and the water stratum of the testing device.

   c. When the total numbers of the foulers in Figs. 1-3 are similarly graphed for a two-week or a four-week period, a pronounced stratum differential is noted in (a) numbers of an individual species, and (b) sequential seasonal picture.

   d. Mytilus edulis (spat) is present (a) at the surface from February through June (maximum in May and June), (b) at mid-depth from January through April and again in November (maximum February through April), and (c) at the bottom from March through May (maximum in May). Although Mytilus is found for the longest unbroken period at the surface, it appears first at mid-depth and attains maximum abundance there. Greatest numbers at the surface and bottom occur in the same month (May).

   e. Obelia sp. (No gonangia have been observed thus far during the entire investigation). Obelia sp. is present (a) at the surface during March, May through June, August through October, and December (maximum in June), (b) at mid-depth from May through July and in September (maxima apparently insignificant), and (c) at the bottom from January through March, again in June, August, and November through December (maxima apparently insignificant). Obelia sp. appears in greatest numbers at the surface in June, but is most abundant throughout the year at the bottom.

f. The anchor and cable from the bottom to three inches below the bottom box have rarely been fouled. There is no accepted explanation for this as yet. Occasionally the scouring has affected the bottom box also.

g. Sediment, mud and detritus are maximal on the test slides at this station. This probably accounts for the low light penetration in this area as indicated by Secchi disk readings.

7. An examination of Figures 4 through 6 reveals that similar conclusions may be drawn concerning numbers of foulers and their seasonal appearance at Station BAKER: Sect. 6, Nos. a, b, c (see above) apply especially.

a. Not only during 1956 but also during 1955, the fouling community at Station BAKER was larger in terms of total biomass than at Station ABLE.

b. Mytilus edulis (spat) is present (a) at the surface from February through April, September through October, and December (maximum in September); (b) at mid-depth in January, April, June and October (maximum in April); and (c) at the bottom in January, April, July and November (no significant maximum). The occurrence of spat at this station in nearly every month indicates that Mytilus spawns here throughout the year. This is an indication of greater Mytilus fouling in the BAKER area than in the ABLE area. Here, as at station ABLE, maximum fouling by Mytilus occurs at mid-depth and the longest unbroken period of fouling is at the surface.

c. Obelia sp. occurs (a) at the surface from May through October (maximum during May and June); (b) at mid-depth from May through October (maximum during June); and (c) at the bottom from April through September, and November through December (maximum during May and June). As at Station ABLE, Obelia sp. fouls in greatest number in June from top to bottom, and also it grows maximally and for the greatest length of time at the bottom.

d. At this station, scouring at the bottom is not as extensive vertically as at ABLE. There is reason to suspect that tidal turbulence may be an important causative factor.

e. Detritus and sediment are minimal on the test slides. In place of mud, the slides often have microscopic quartz grains apparently washed from the sandy beaches.

C. Fouling of 5-Box Apparatus (Station DOCK)

1. The top and bottom temperature curves for 1956 at Station DOCK are similar to those of Stations ABLE and BAKER, but they resemble more closely those at ABLE than those at BAKER (Figs. 1, 4 and 7).

2. Many of the differences in fouling, noted below, between DOCK on the one hand, and ABLE and BAKER on the other, may be reasonably ascribed to the position of the test slides. It will be remembered that the test slides in ABLE and BAKER were maintained vertically, whereas those at DOCK were held horizontally (parallel to the bottom). No tests were made to correlate this difference in position; the above assumption is based on the fouling accumulations at different positions on test objects (Ref. No. 56-11).

3. Each test slide at this Station had an area of 19.35 sq. cm. per side compared with the 129.03 sq. cm. of the ABLE and BAKER test slides, but the fouling biomass, per unit of time and area, was greater at DOCK than at ABLE and BAKER.

4. The edges of the slides that faced away from the dock were fouled nearly twice as heavily as the opposite edge. The fouling along the edges was composed almost entirely of solitary, colonial and filamentous diatoms, with an occasional small algal filament or a hydroid. No final explanation for this radical difference in the fouling of narrowly separated, precisely similar substrates can be given at this time; presumably current and light are important factors.

5. The tops of the horizontal slides at Station DOCK were always covered with a far greater mass of the foulers than were the bottoms of these slides. The original accumulations, such as bacteria, diatoms, hydroids and ciliates, were fairly equal on both sides, but from this point on, the building of the fouling community was entirely one-sided. This was especially noted with the foraminifera, bryozoa, tunicates, sponges, mussels and most hydroids.

6. The small slide used in this series of boxes was far superior to the larger slides with regard to making a detailed analysis of time, rate, and types of fouling growth. The reasons for this are (a) ease of handling, (b) suitability for direct microscopic examination, (c) facility of permanentization, (d) availability, (e) relative low cost, (f) adaptability to experiment and (g) transportability.

7. Although a series of five boxes at equal intervals from the surface to the bottom (Ref. No. 56-11, Fig. 2) were used, only the surface, mid-depth and bottom boxes have been included in this report (Figs. 7, 8, 9) for comparison with the fouling at Stations ABLE and BAKER. Suffice it to state that a consistent relationship between the depth and the amount and types of fouling has been shown in this location.

a. The total amount of fouling was greatest at the surface and least at the bottom. (This is shown in Figs. 7, 8 and 9).

b. There was a gradual decrease in filamentous algae, filamentous diatoms, colonial diatoms, and solitary diatoms from the surface to the bottom (filamentous algae were rarely found at mid-depth or below).

c. The amount of sedimentary detritus and quartz grains settling on the slides was greatest at mid-depth and least on the bottom box and slides.

8. A series of experiments with the 5-box apparatus designed to show the length of time necessary for fouling to start on submerged artifacts showed that both bacteria and diatoms will attach within 24 hours when the temperature of the water is above 15°C, and the remainder of the fouling community will build up accordingly. Growth of this community is more rapid in warm than in cold waters in this locality. The chief sequence of fouling organisms in this particular experiment was one of size rather than of species, the smaller organisms attaching first followed by the larger ones. More work remains to be done in this area.

9. Because regular observations were not completely organized until June, the observations recorded in Figs. 7, 8 and 9 are complete only for the second half of 1956.

a. Mytilus edulis (spat) was found (a) at the surface from July through December (minor maxima in August and in October), (b) at mid-depth in July and August, from October through December (maximum in November), and (c) at the bottom from October through December (no maximum). Mytilus shows maximum abundance at mid-depth but appears for the longest unbroken period at the surface.

b. Obelia sp. attached (a) at the surface in July and August, and October and November (maximum in July), (b) at mid-depth in October and November (no maximum) and (c) at the bottom in August and September (minor maximum in September). Obelia sp. appeared for the longest period at the surface and was found in greatest abundance at this level.

c. The anchor and cable below the bottom box were nearly as clean as those at ABLE and BAKER. The reasons for an absence of attaching organisms on these objects at the lowest stratum are not yet known.

10. There is reason to believe from some of the observations at DOCK that the proximity of the test artifacts to other artifacts already fouled, such as pilings, may have some influence on the quantity and types of foulers of the experimental slides. Gross examination indicates that this would hold better for the larger and later foulers than for the earlier, smaller organisms. Here again further investigation is recommended.

D. Fouling of the 1-Box Apparatus

Little can be added to the conclusions drawn for this device, located at Stations ABIE and BAKER, noted on page 4 of Ref. No. 56-11. Because of repeated breakage and loss it has become evident that at least in this area this is a very unsatisfactory apparatus for the purpose for which it was designed.

PLANS FOR FUTURE

The experimental study of some problems raised in the present project is the subject of a proposal being formulated for submission to the Office of Naval Research.

EXPLANATION OF FIGURES

Key to organisms:

A - Small ciliates

B - *Crepidula fornicata*

C - Folliculina sp.

D - *Mytilus edulis*

E - Obelia sp.

F - Detritus trees

A line indicates a trace; greater abundance is indicated semi-quantitatively.

Fig. 1 - Station ABLE in Narragansett Bay. Fouling on vertical glass plates exposed for periods of one week at the surface during 1956. Temperature in ° Centigrade at this station in monthly averages.

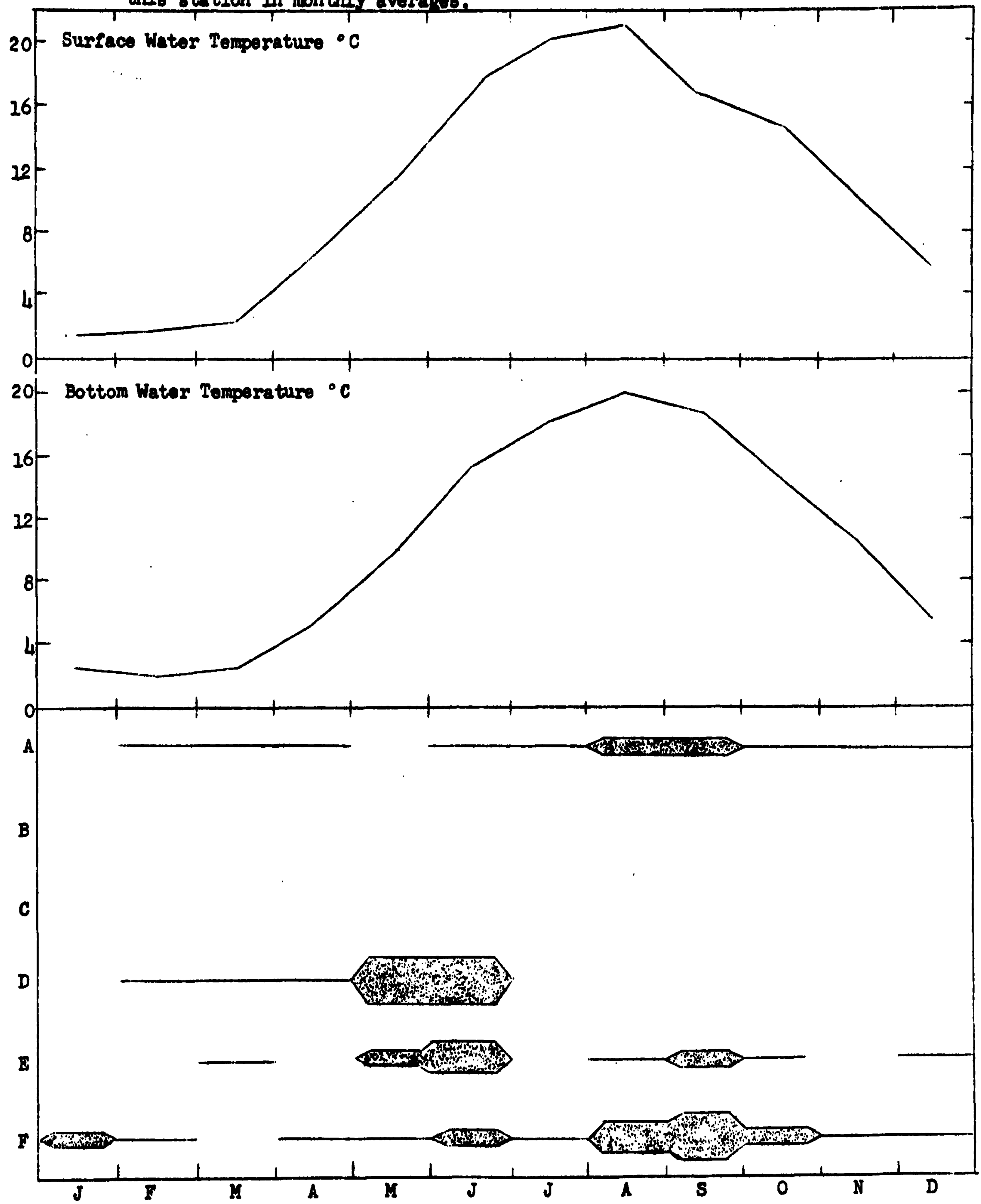


Fig. 2 - Station ABLE in Narragansett Bay. Fouling on vertical glass plates exposed for periods of one week at mid-depth during 1956. Temperature in ° C at this station in monthly averages

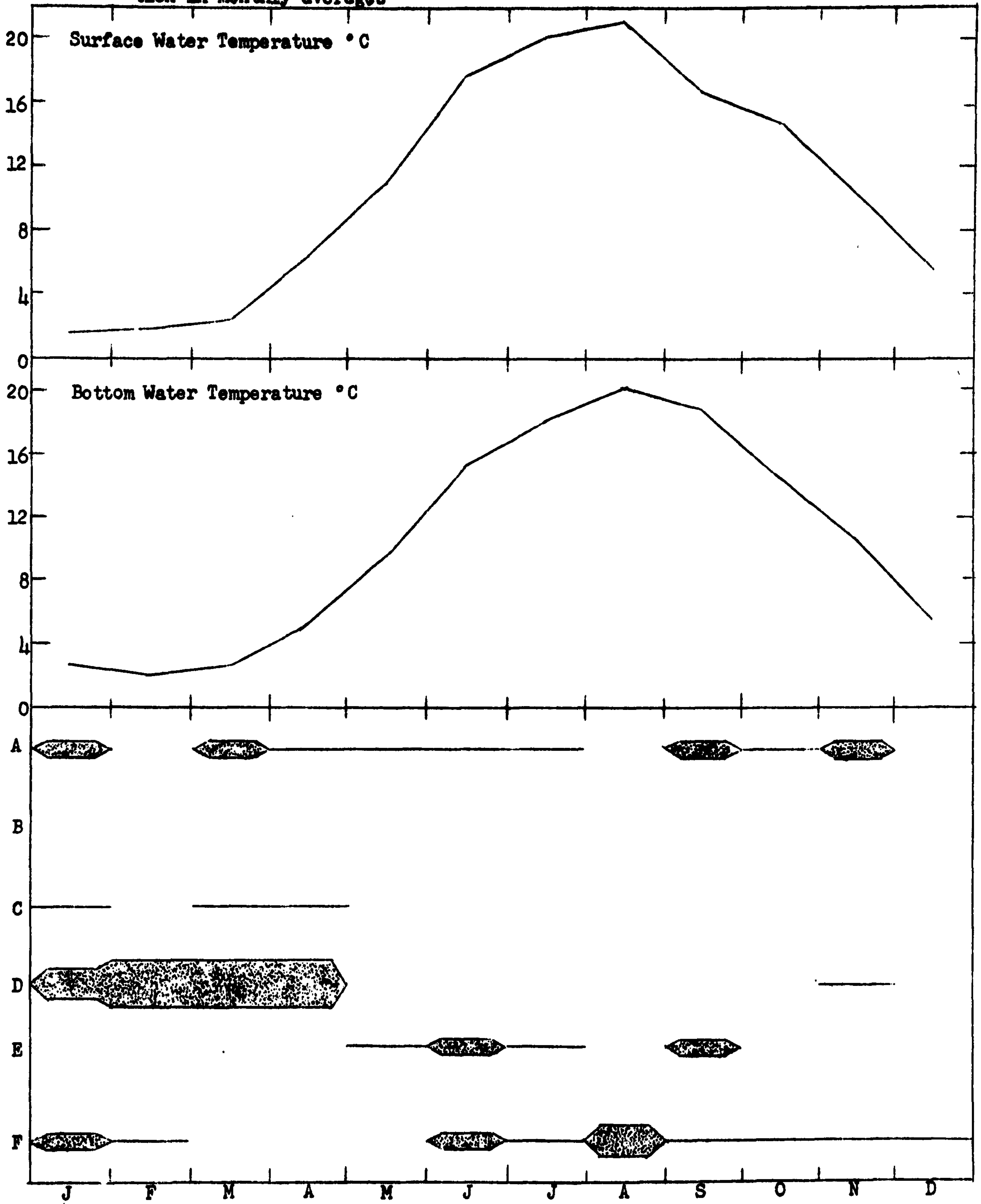


Fig. 3 - Station ABLE in Narragansett Bay. Fouling on vertical glass plates exposed for periods of one week near the bottom during 1956. Temperature in ° C at this station in monthly averages.

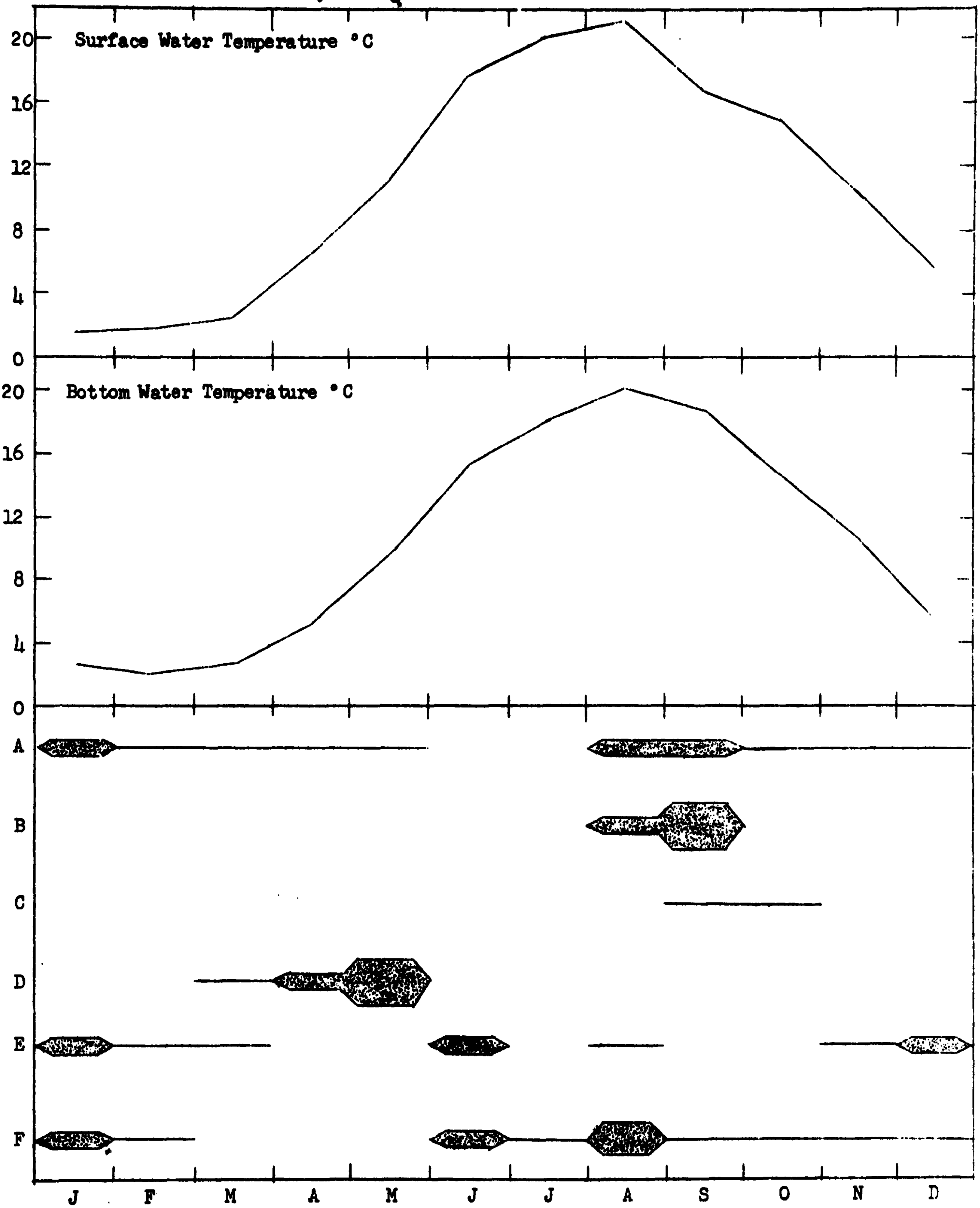


Fig. 4 - Station BAKER in Block Island Sound. Fouling on vertical glass plates exposed for periods of one week at the surface during 1956. Temperature in ° C at this station in monthly averages.

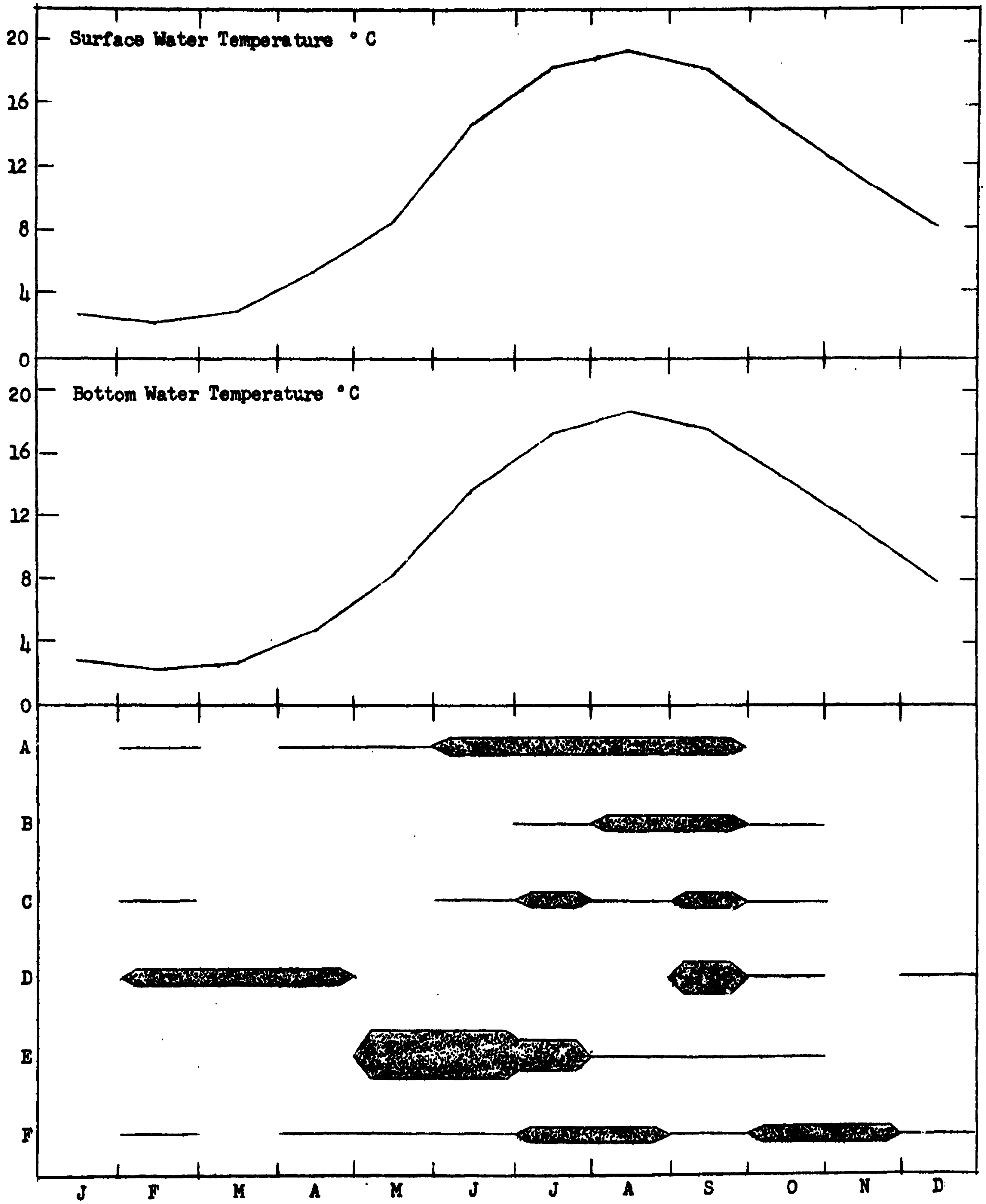


Fig. 5 - Station BAKER in Block Island Sound. Fouling on vertical glass plates exposed for periods of one week at mid-depth during 1956. Temperature in ° C at this station in monthly averages.

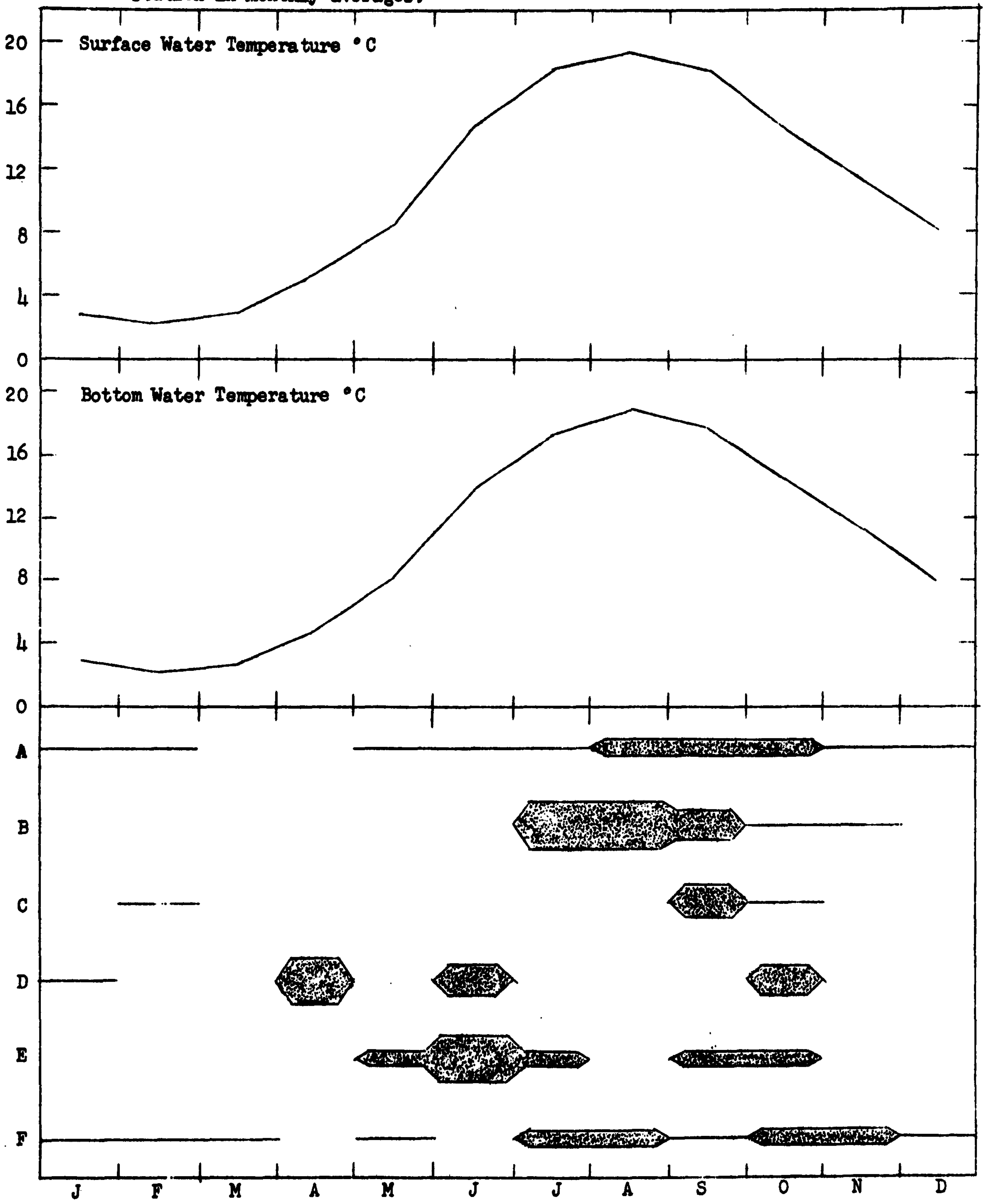


Fig. 6 - Station BAKER in Block Island Sound. Fouling on vertical glass plates exposed for periods of one week near the bottom during 1956. Temperature in ° C at this station in monthly averages.

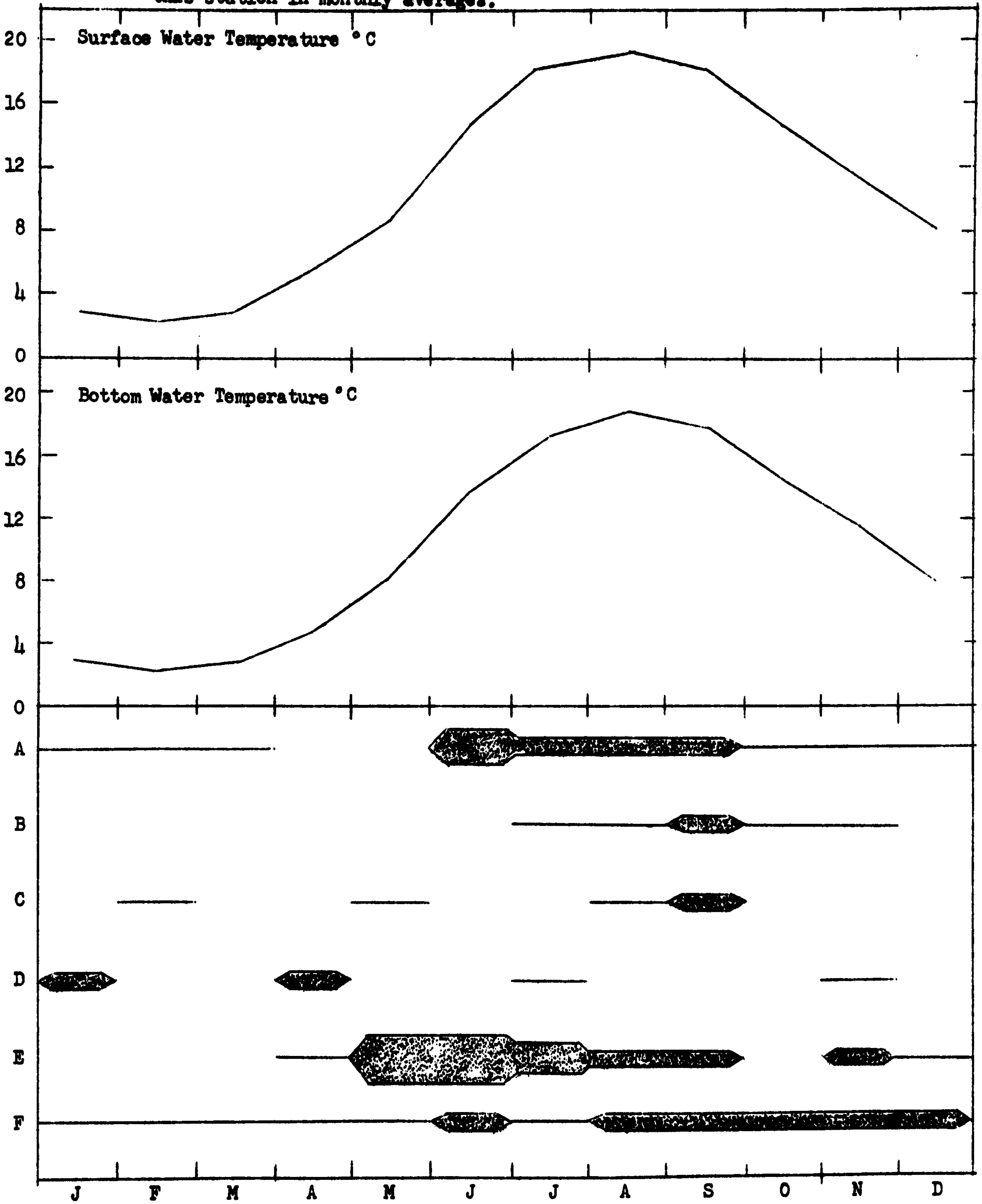


Fig. 7 - Station DOCK at the Narragansett Marine Laboratory. Fouling on horizontal standard microscope slides exposed for one-week periods at the surface during 1956. Temperature in ° C at this station in monthly averages.

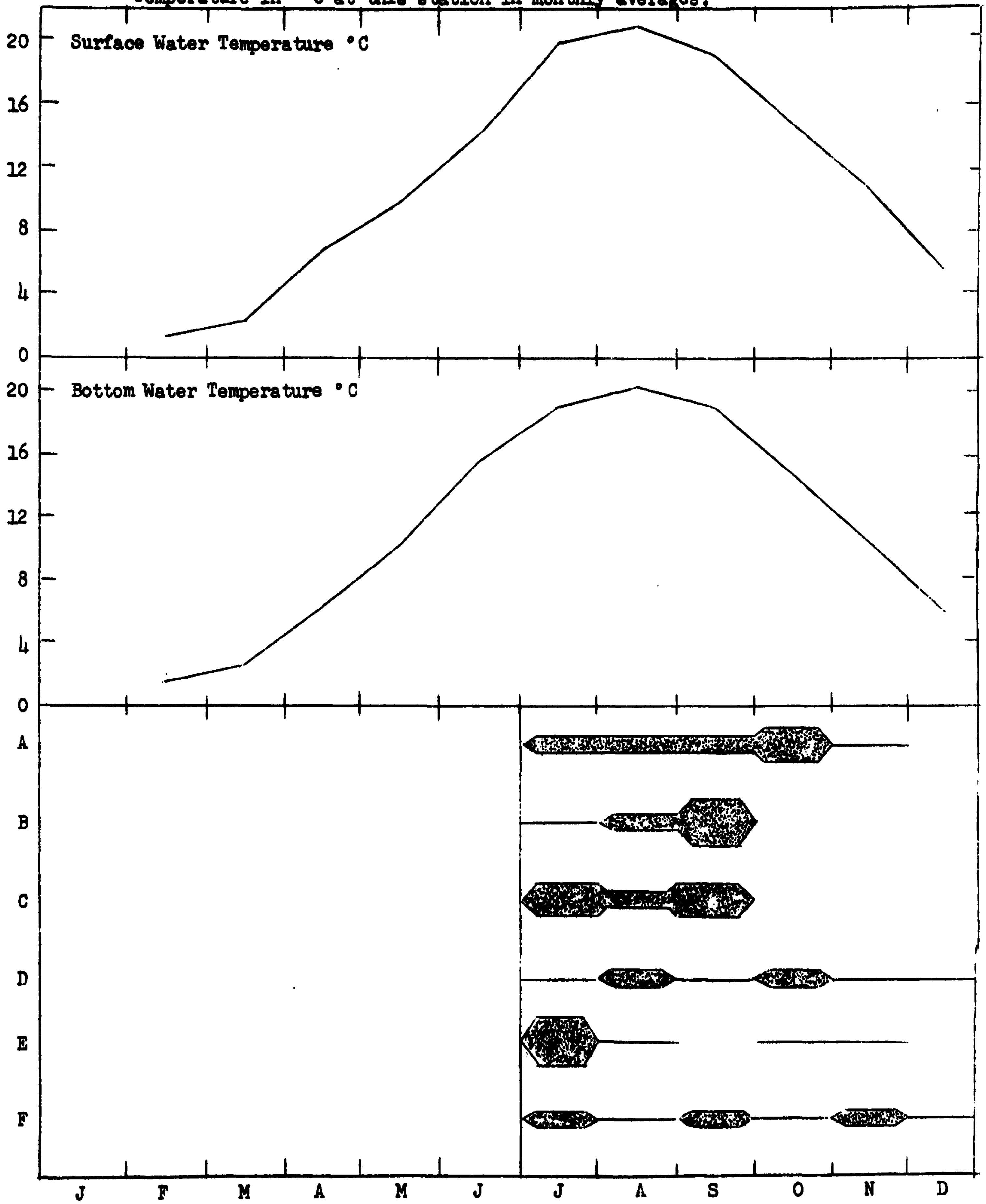


Fig. 8 - Station DOCK at the Narragansett Marine Laboratory. Fouling on horizontal standard microscope slides exposed for one-week periods at mid-depth during 1956. Temperature in ° C at this station in monthly averages.

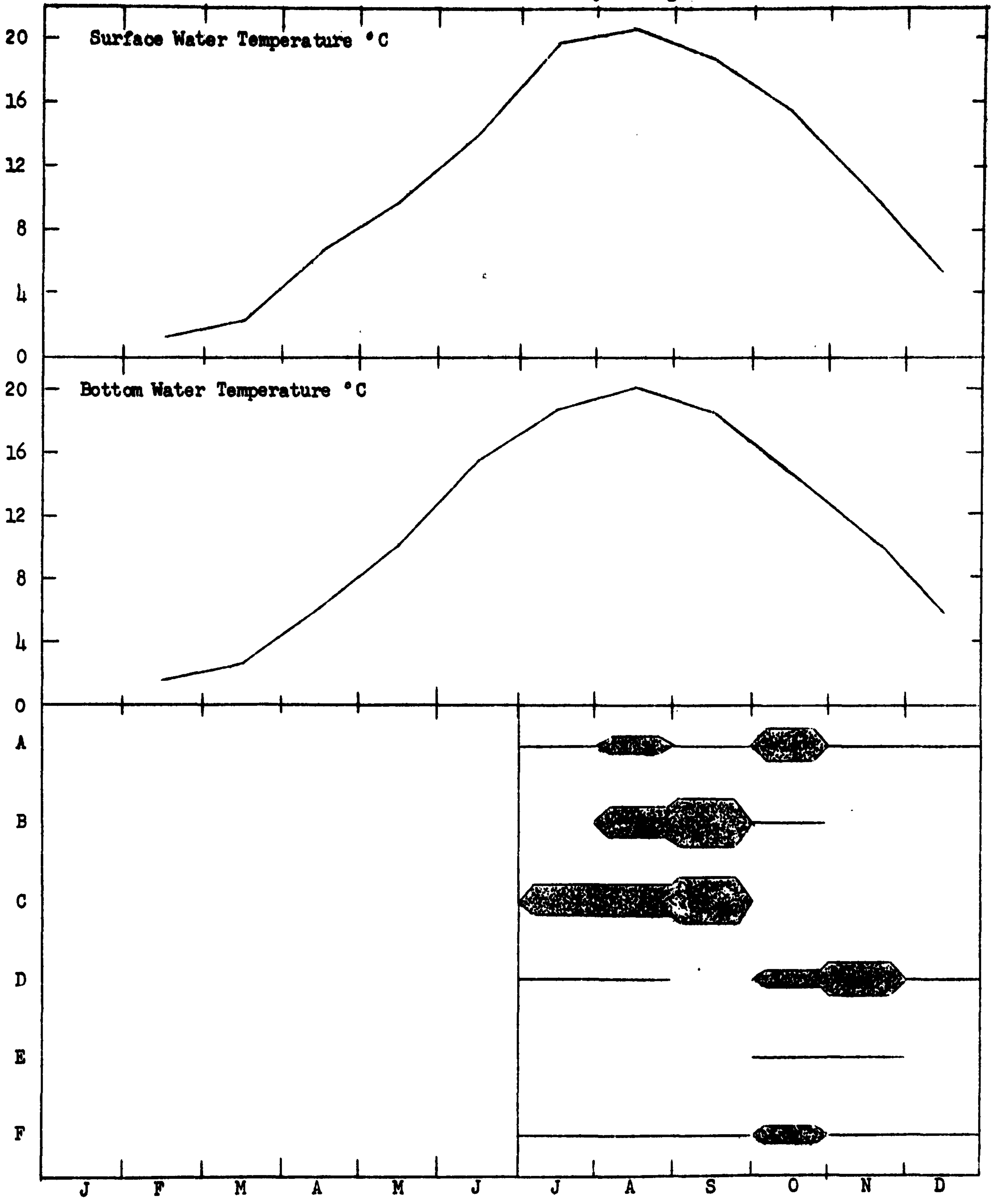
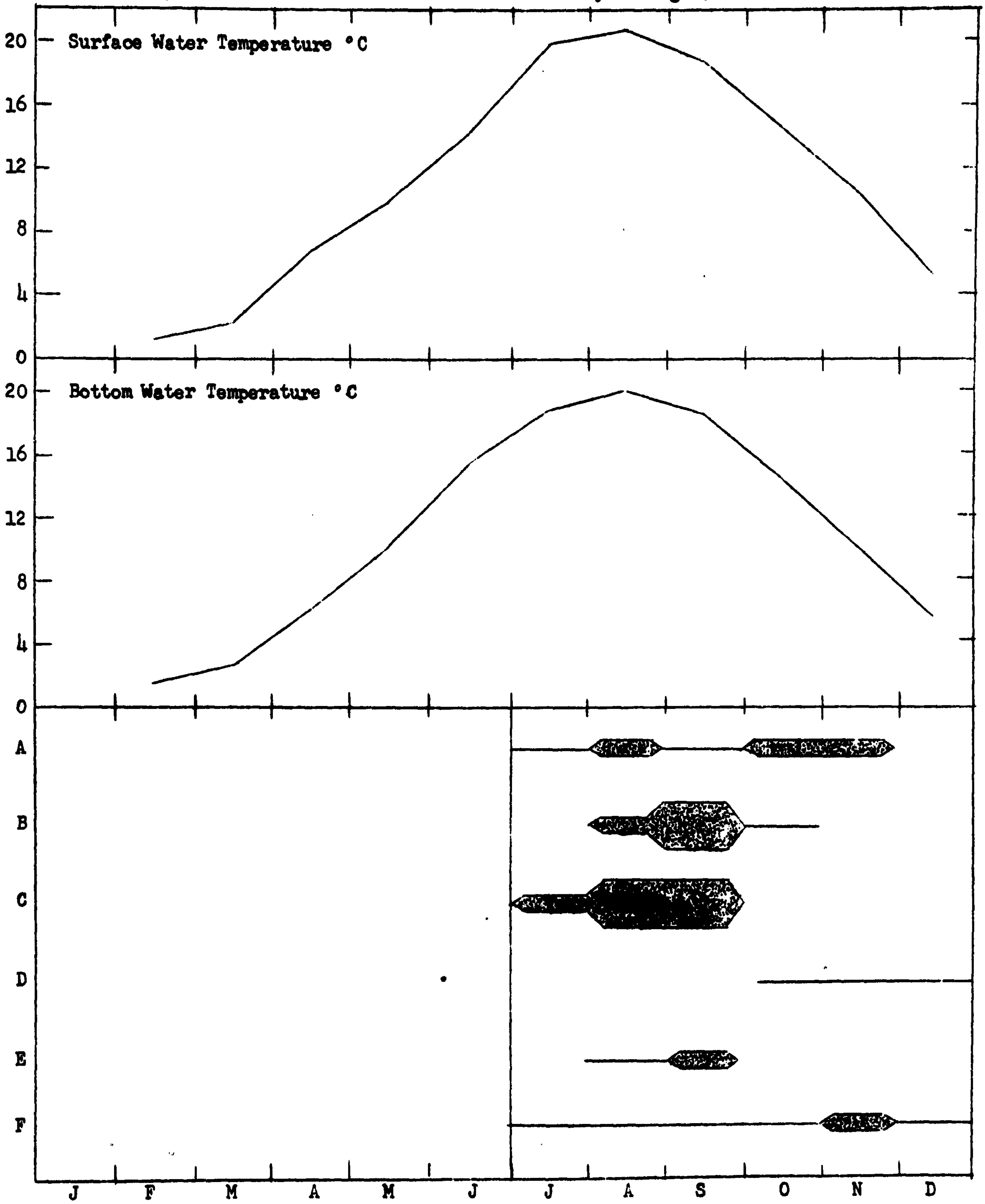


Fig. 9 - Station DOCK at the Narragansett Marine Laboratory. Fouling on horizontal standard microscope slides exposed for one-week periods at the bottom during 1956. Temperature in ° C at this station in monthly averages.



APPENDIX

List of organisms collected on test panels

ANIMALS

1. Acoels
2. Aeolis sp.
3. Aeolis sp. Tracks
4. Amphipod Tubes
5. Amphithoe sp.
6. Anemones
7. Asterias sp.
8. Autolytus sp.
9. Balanus sp.
10. Barnacles
11. Bougainvillia sp.
12. *Bougainvillia carolinensis*
13. Bryozoa (encrusting)
14. *Bugula flabellata*
15. Byssus Patches (of Mytilus)
16. Campanularia sp.
17. Caprellids
18. Caprella sp.
19. Chthalamus sp.
20. Ciliates, Large
21. Ciliates, Small
22. Ciliates, Vase Shaped
23. *Ciona intestinalis*
24. *Columbella avara*
25. *Corophium cylindricum*
26. *Crepidula fornicata*
27. *Crisia eburnea*
28. Detritus tubes
29. Egg Cluster (kidney shaped)
30. Egg Clutches
31. Eggs, Gastropod
32. Eggs, Nudibranch
33. Eudendrium sp.
34. Euplotidae
35. Fecal Pellets
36. Flagellates
37. Folliculina sp.
38. *Folliculina producta*
39. Foraminifera I
40. Foraminifera II
41. Gastrotrichs
42. Harpacticoid Adults
43. Harpacticoid Copepodids
44. Harpacticoid Nauplii
45. Hydroid Stalks
46. *Hydroides hexagonus*
47. Isopods
48. Kinorhynchs
49. Membranipora sp.
50. *Metridium dianthus*
51. Mites
52. *Mitrella lunata*
53. *Modiolus modiolus*
54. *Molgula manhattensis*
55. *Mytilus edulis*
56. Nematodes
57. Obelia sp.
58. *Obelia commisuralis*
59. *Obelia dichotoma*
60. *Obelia geniculata*
61. Ostracods
62. Polychaetes
63. Prototrochs
64. Pycnogonids
65. Quarts Tubes
66. Radiolaria
67. Rhabdocoels
68. Rotifers
69. Schizoporella sp.
70. Slime Tracks
71. Spirostomum sp.
72. *Spirostomum teres*
73. Sponges
74. Halichondria sp.
75. Suctoria I
76. *Acineta tuberosa*
77. Suctoria II
78. Podophyra sp.
79. Suctoria III
80. *Podophrya gracilis*
81. *Syncoryne exima*
82. Testacea
83. Gromia sp.
84. Tintinnoids
85. *Tubularia crocea*
86. Tubularia Stalks
87. *Unicola irrorata*
88. *Urosalpynx cinereus*
89. Vorticellids
90. Vorticella sp.
91. Worm Tubes
92. Zoothamnium sp.

PLANTS

1. Actinomycetes
2. Algae, Filamentous
3. Bacteria, Stalked (Dark)
4. Bacteria, Stalked (Light)
5. Biddulphia sp.
6. Ceramium sp.
7. Chondrus crispus
8. Cocconeis sp.
9. Coccinodiscus sp.
10. Caldophora sp.
11. Cymbella sp.
12. Detritus trees
13. Diatoms, Colonial
14. Diatoms, Filamentous
15. Diatoms, Solitary
16. Ectocarpus sp.
17. Enteromorpha sp.
18. Fragilaria sp.
19. Gomphonema sp.
20. Grammatophora sp.
21. Liomophora sp.
22. Melosira sp. I
23. Melosira sp. II
24. Melosira sp. III
25. Mycelia
26. Navicula sp.
27. Navicula types
28. Nitzchia sp.
29. Oscillatoria sp.
30. Pleurosigma sp.
31. Polysiphonia sp.
32. Rhabdonema sp.
33. Rhizosolenia sp.
34. Rhodymenia sp.
35. Spermathamnion sp.
36. Synedra sp.
37. Tabellaria sp.
38. Thalassionema sp.
39. Thalassiosira sp.
40. Ulothrix sp.
41. Ulva sp.
42. Yeast, Colorless
43. Yeast, Red
44. Yeast, Yellow

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